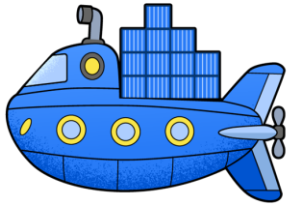

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NExt Generation Meta Operating System

NEMO MetaOS Adding Value in Smart Farming

26th InfoCom World Conference, Athens

12 November 2024

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Synelixis Solutions SA

NEMO receives funding from the EU Horizon Europe research and innovation Programme under Grant Agreement No. 101070118

Smart Farming Living Lab

- **Location**
  - Agia Sofia estate, Monemvasia, Greece
- **Objective**
  - Protection of olive trees from olive fruit fly through aerial spraying
  - Optimization of the use of bio-spraying, without compromising organic certification
  - Efficient and responsible resource utilization within the Smart Farm
- **Partners**

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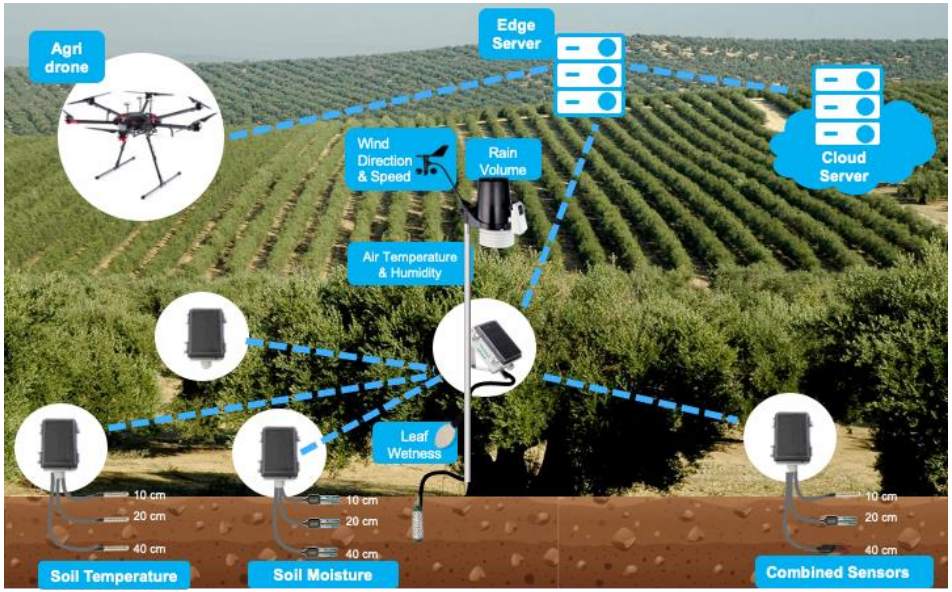
Smart Farming Use Cases

Aerial Precision Bio-Spraying

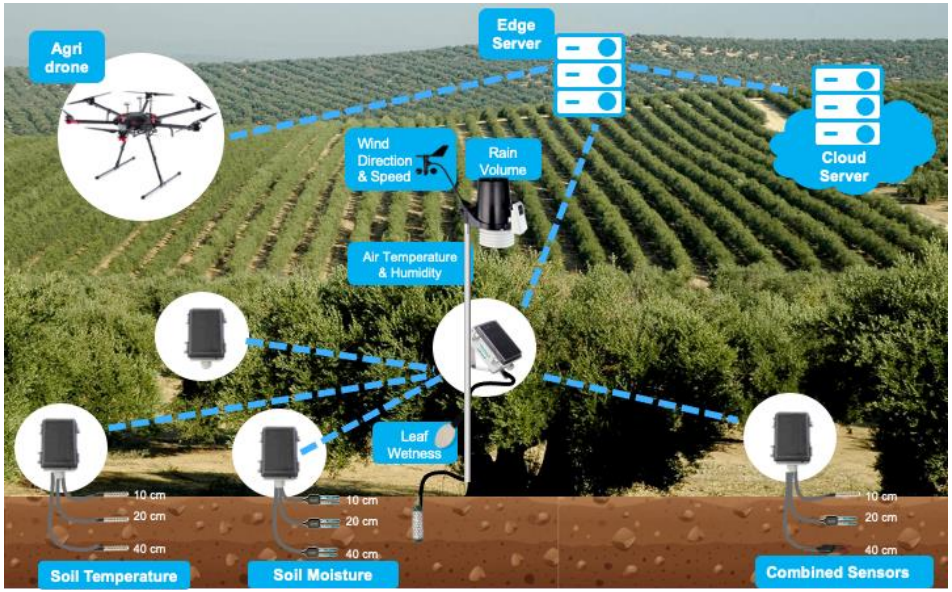
- **Concept**
  - Micro-clima data collected via Synelixis *SynField® IoT* nodes
  - Real-time video analysis of olive groves from visual and multi-spectral cameras attached on semi-autonomous *drones* to identify in real-time where bio-spraying is needed.
  - The bio-spraying decision will be based on ML models, which will run *on the end devices* (drones)
  - Increased model performance and energy efficiency will be investigated during the *training* process through
    - Cybersecure Federated Deep Reinforcement Learning (CF-DRL), and
    - Flexible deployment of the training jobs across the IoT, edge and cloud resources available.



Smart Farming Use Cases

Aerial Precision Bio-Spraying

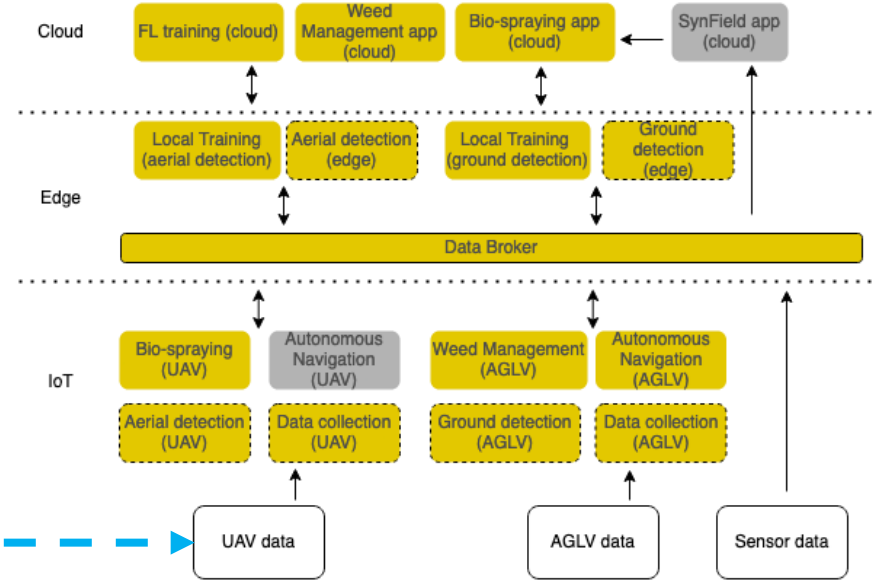
- **Benefits**
  - Protection of olive trees from olive fruit fly through aerial spraying
  - Increased energy efficiency through flexible deployment of services IoT-edge-cloud continuum
  - Reduction of CO_2 emissions by moving operations closer to the edge or better exploiting green energy availability
  - Efficient and responsible resource utilization within the Smart Farm



Technical introduction to Smart Farming use case

- **Overview**: The Smart Farming use case involves using a **UAV** to perform an olive tree segmentation task for precision aerial bio-spraying**.**
- **Objective**: To validate Nemo Meta-OS capabilities in running ML-based applications on UAV, edge, or cloud devices for olive tree segmentation and assisting in aerial bio-spraying. The potential of executing the ML based application on different levels of the continuum will be evaluated with the aim to achieve high application performance and low latency to allow aerial spraying.
- **Key Outcome**: Efficient workload balancing across NEMO resources**.**

Smart Farming Pilot Infrastructure



SynField

https://www.synfield.gr/

NEMO Meta-OS for Smart Farming

- **What is NEMO Meta-OS**: A cloud-native, distributed meta operating system (meta-os) designed to orchestrate and manage workloads across edge, cloud, and IoT environments. NEMO meta-os enables cybersecure, flexible and efficient automated orchestration of both computing workloads, computing and network resources dispersed in IoT, edge and cloud, possibly across domains and for multiple stakeholders

- **Main Features**: Adaptive resource management, distributed computing, and microservice architecture.

- **Goal**: To intelligently allocate workloads based on available resources and context requirements.

Key Functionalities of NEMO Meta-OS

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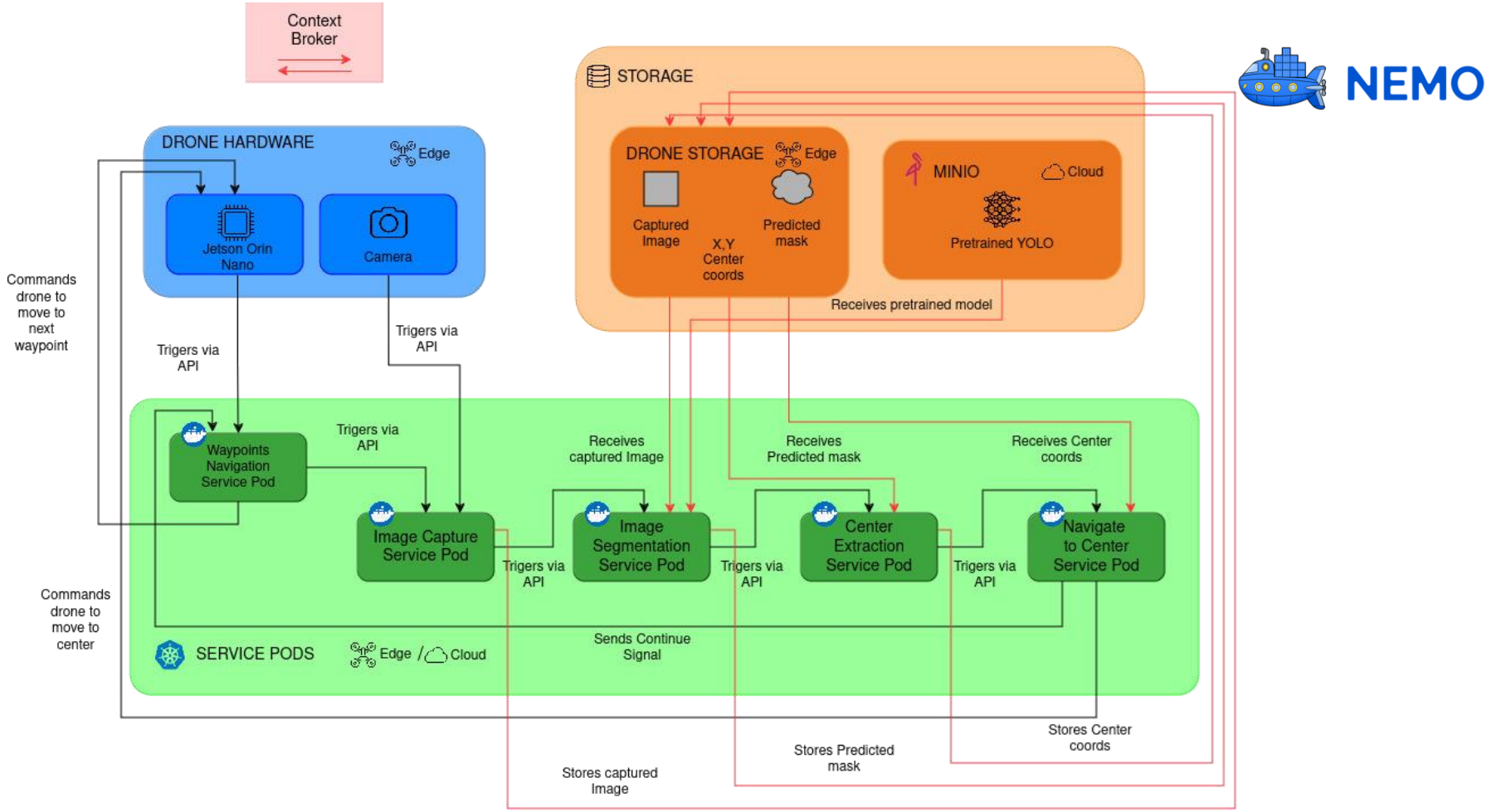
- **Adaptive Workload Allocation**: Automatically adjusts where the workload should be executed (cloud, edge, or IoT).
- **Microservices and Modular Flexibility**: Enables modular deployment of different parts of the application, simplifying updates and management.
- **Scalability**: Seamlessly scales up or down based on workload requirements and available resources.

Overview of the Olive Tree Segmentation Pipeline

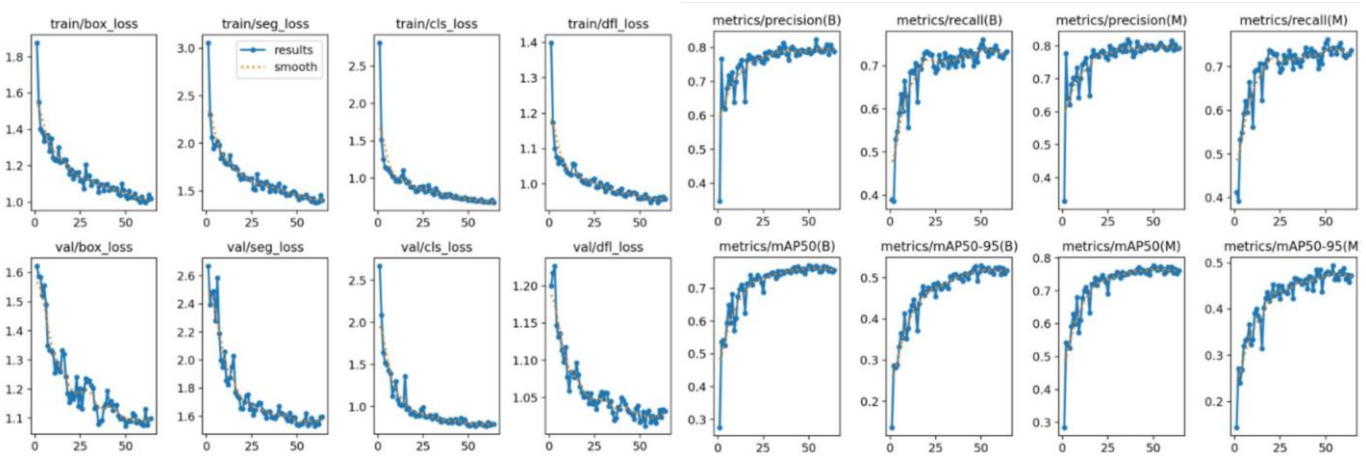
- **Navigation**: Waypoint navigation with task triggering upon reaching each waypoint.

- **Triggered Task Pipeline**:
  - **Step 1**: Image capturing
  - **Step 2**: Segmentation using machine learning models
  - **Step 3**: Mask's center coordinates extraction
  - **Step 4**: Navigation to center coordinates and resume waypoint navigation

- **Challenge**: Managing different computational requirements for each step.


Context Broker
STORAGE
NEMO
DRONE HARDWARE
Edge
Jetson Orin Nano
Camera
DRONE STORAGE
Edge
Captured Image
X,Y Center coords
Predicted mask
MINIO
Cloud
Pretrained YOLO
Receives pretrained model
Commands drone to move to next waypoint
Trigers via API
Trigers via API
Waypoints Navigation Service Pod
Trigers via API
Image Capture Service Pod
Receives captured Image
Image Segmentation Service Pod
Receives Predicted mask
Center Extraction Service Pod
Receives Center coords
Navigate to Center Service Pod
Trigers via API
Trigers via API
Trigers via API
Commands drone to move to center
SERVICE PODS
Edge / Cloud
Sends Continue Signal
Stores Center coords
Stores Predicted mask
Stores captured Image

Initial Results



Fine-tuning YOLOv8n-seg for segmentation

Initial image and segmentation with YOLOv8n-seg

Papers Published

- Prousalidis, K.; Bourou, S.; Velivassaki, T.-H.; Voulkidis, A.; Zachariadi, A.; Zachariadis, V. Olive Tree Segmentation from UAV Imagery. Drones 2024, 8, 408. https://doi.org/10.3390/drones8080408
- Anastasakis, Z., Velivassaki, T. H., Voulkidis, A., Bourou, S., Psychogyios, K., Skias, D., & Zahariadis, T. (2023). FREDY: Federated Resilience Enhanced with Differential Privacy. *Future Internet*, *15*(9), 296. https://doi.org/10.3390/fi15090296

How NEMO Meta-OS Supports the Use Case

- **Dynamic Load Migration**: NEMO Meta-OS dynamically migrates computational loads between UAV, edge, and cloud nodes based on current usage, available resources, and the nature of tasks.
  - Ensures that resource-intensive tasks are shifted to more powerful nodes when needed.
  - Avoids bottlenecks by distributing workloads optimally in real-time.
  - Minimizes energy consumption by running lightweight tasks on edge devices when feasible.

- **Microservices for Each Processing Stage**:
  - Data capturing, segmentation, and result analysis, navigation each implemented as independent microservices.
  - Improved modularity, easy updates, and fault tolerance.

- **Scalability and Flexibility**: Each service can scale independently based on the workload.

Real-World Impact of using NEMO Meta-OS

- **Precision Agriculture**: Provides critical insights for optimizing olive tree health and improving crop yields.
- **Operational Efficiency**: Intelligent workload distribution reduces the time and costs involved in processing large datasets.
- **Scalability**: System can be easily expanded to handle more agricultural sites or additional types of crops.

Thank you for your attention

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